The PHENIX Muon Trigger Upgrade Level-1 Trigger System
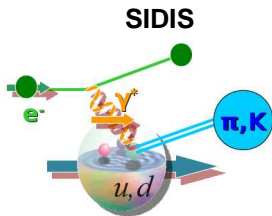
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Motivation: Flavor Separated Longitudinal Quark Distributions
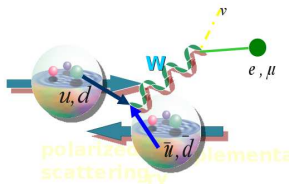Probes Sensitive to Quark Flavors in Polarized Protons:

SIDIS

Advantage:
Only probing one proton.

Disadvantage:
Unfolding depends heavily on fragmentation functions.

W production in p+p

Advantage:
Clean probe. No fragmentation function.

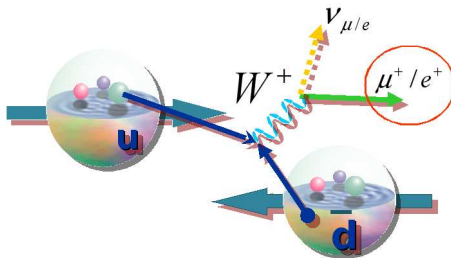Disadvantage:
Probing 2 protons. Can't measure W directly.

W Production Basics

PHENIX can measure leptonic decays:

$$u\bar{d} \rightarrow W^+ \rightarrow l^+\nu_l$$
$$\bar{u}d \rightarrow W^- \rightarrow l^-\bar{\nu}_l$$

Since the W is maximally parity violating, asymmetries relate directly to the helicity structure of the proton.

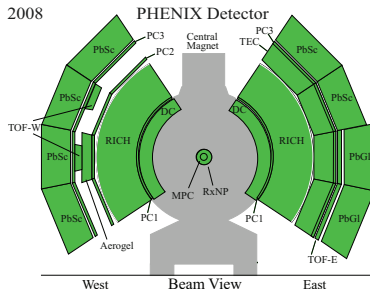Single Longitudinal Spin Asymmetry:

$$A_L^{W^+} = \frac{\sigma^\uparrow - \sigma^\downarrow}{\sigma^\uparrow + \sigma^\downarrow} \propto \frac{\Delta\bar{d}(x_1)u(x_2) - \Delta u(x_1)d(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}$$

(Similar expression for W^- to get $\Delta\bar{u}$ and Δd)

The PHENIX Experiment
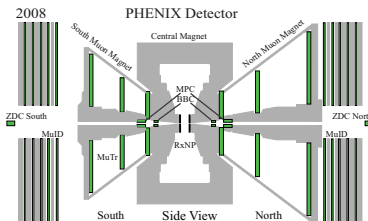High Rate Capability and Granularity with a Limited Acceptance

Central Arm Electron Detection

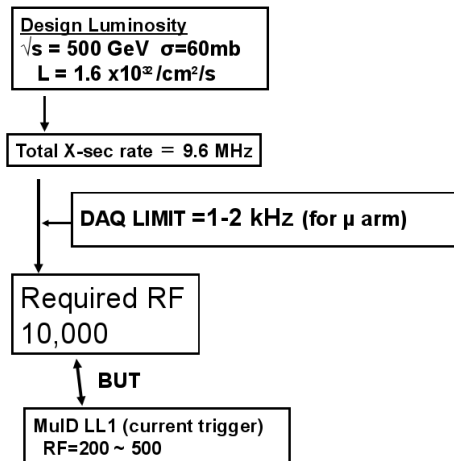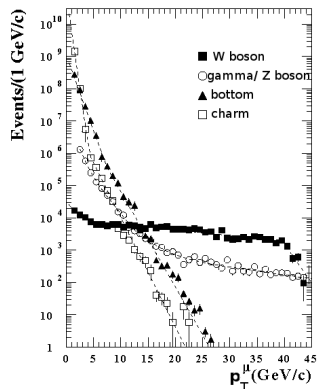▶ $|\eta| < 0.35$, $\Delta\phi = 2 \times \frac{\pi}{2}$

Already capable of measuring Ws.
(See talk by John Haggerty in session S8)

Forward Muon Spectrometers

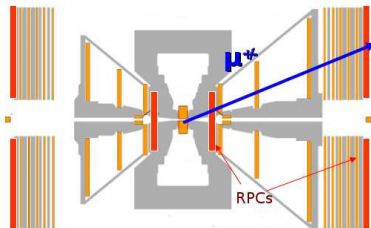▶ $1.2 < \eta < 2.2$, $\Delta\phi = 2\pi$

In need of a trigger upgrade to measure
Ws (next slide)

Inclusive μ Production, 500 GeV/c

Design Luminosity
$\sqrt{s}$ = 500 GeV σ=60mb
L = 1.6 x10³² /cm²/s

↓

Total X-sec rate = 9.6 MHz

↓

DAQ LIMIT =1-2 kHz (for μ arm)

Required RF 10,000

BUT

MuID LL1 (current trigger)
RF=200 ~ 500

One Solution: Momentum Selectivity in the Lvl-1 Trigger!

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Trigger Concept

1. Instrument Muon Tracker Front End Electronics (FEEs) with Trigger Readout

2. Install Resistive Plate Chambers (RPCs) to determine crossing and reject beam-related background

3. Install newly designed Level-1 electronics to make trigger decision

Physics and PHENIX
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Trigger Concept
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Trigger Implementation
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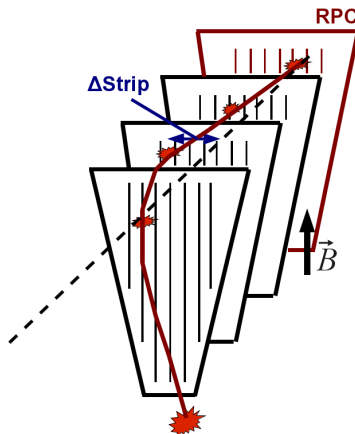
Hardware Chain
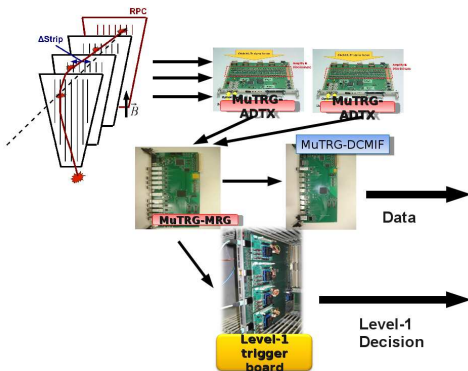
- ▶ Data from detectors goes to amplifier/discriminator (ADTX) boards

- ▶ ADTX boards are 'merged' by the MRG boards, which transmit to the data collection interface (DCMIF) and Local-Level 1 (LL1) boards

- ▶ LL1 decision is passed to a global-level 1 (GL1), and data is written out by a data collection module (DCM)

Physics and PHENIX
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Trigger Concept
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Trigger Implementation
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## Trigger Hardware Concept
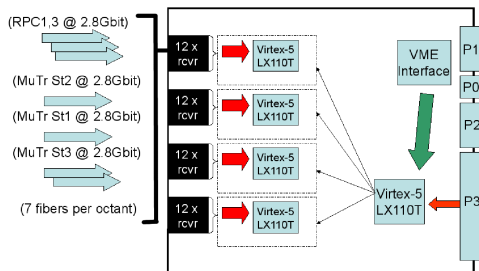
- ▶ Data comes in from MTP fibers
- ▶ Trigger 'tiles' demux the data and run the algorithm
- ▶ Baseboard FPGA recieves trigger decision from tiles and sends it out through VME backplane
- ▶ Commands are sent to 'baseboard' FPGA over VME interface
- ▶ Baseboard FPGA controls tile power through i^2c interface

Trigger Hardware

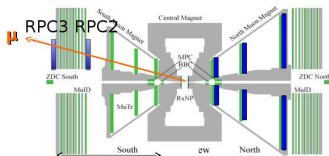Modular 'Tiles'

9U VME 'baseboard'
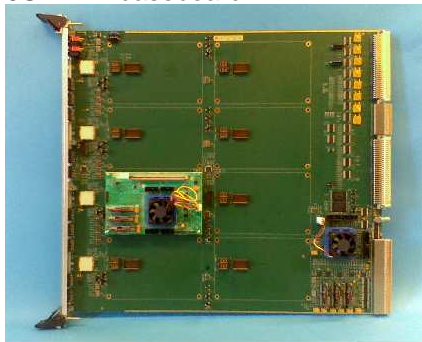
- ▶ Tiles and Baseboard populated with Virtex-5 FPGAs
- ▶ 4 Avago SNAP-12 fiber recievers on each board will operate at 2.8 Gbps/fiber
- ▶ Tiles constructed with Rogers material instead of traditional FR4 to facilitate high speed communication.
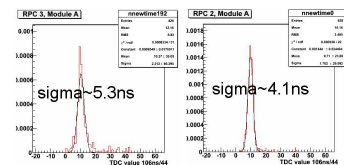
Muon Tracker Front-End Electronics

- ▶ North Arm was installed and tested during spring 2009 Physics run.

- ▶ South Arm was installed during summer 2009 shutdown and is currently being commissioned.

Resistive Plate Chambers

Peak Width ≈3 ns. Measured with half octant prototype during *p+p* running in 2009.
(Bunch crossing width is 106 ns).

- ▶ Prototype RPC was installed and tested during 2009 Physics Run.
- ▶ North Arm Detector was installed during summer 2009 shutdown.
- ▶ South Arm Detector will be installed during summer 2010.
- ▶ For more on the RPCs see the talk by John Hill in session S8 or various talks in this session.
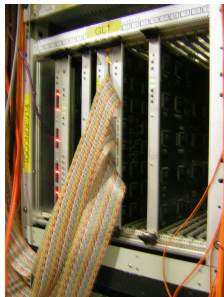
Physics and PHENIX
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Trigger Concept
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Trigger Implementation
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Integrating Level-1 Electronics with the Experiment

Finisar
FTLF8524P2BNV
TX

12.5m 50/125 MMF Fiber

Avago
HFBR-782BEZ
SNAP-12 RX

Muon Tracker
Merging Boards

Lvl1 Baseboard

Front-End → LL1 board
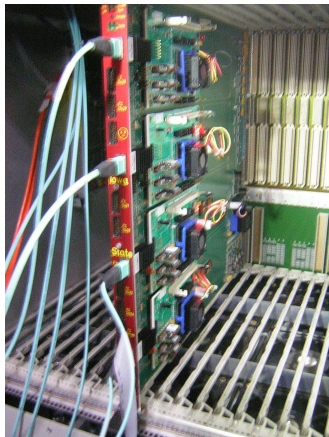
► Tested and found to be stable

► Mapping of incoming channels has been tested and is working.

LL1 → GL1

► Tested and stable.

► Full communication chain is slightly slower than other triggers, and we are working to time it in.

Schedule

- **Spring 2010:** Install North Arm Level-1 Trigger Electronics
- **Summer 2010:** Install South Arm Level-1 Trigger Electronics, Integrate RPCs
- **Winter 2010/2011:** Commission Level-1 electronics and take data. Ready for W physics!

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